Attachment E

Nanocor | Technical Data

Nanomer® Nanoclays are montmorillonite minerals which have been treated with compatabilizing agents, enabling them to disperse to nanoscale size in plastic resins. Montmorillonite is unique among minerals it exists as nanoscale particles which are agglomerated due to surface attraction of one particle to another. When the attractive force is minimized using surface treatment, each particle can disperse to its naturally occurring nanoscale size.

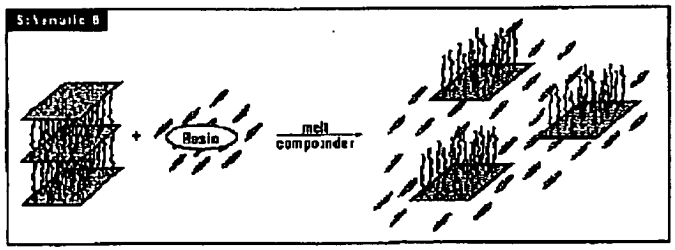
Surface Treatment:

Nanocor uses patented surface treatment technology. As Schematic A illustrates, montmorillonite particles are agglomerated to within a distance of about 3.3Å. Surface treatment reduces particle-particle attraction, promoting an expansion of the distance gallery to above 20Å. At this distance the particles can be separated further either by attaching monomer into the gallery prior to polymerization or in the case of high polymer by employing shearing force using an extrusion compounder.

Schematic A

Schematic B depicts the case where dispersion occurs in the compounding operation. Complete dispersion is called "exfoliation." When Nanomers are exfoliated in a resin matrix, the result is a nanocomposite.

Schematic B



Morphology of Exfoliated Nanomer:

In exfoliated form, Nanomer particles have a flexible sheet-type structure which is remarkable for its very small size, especially the thickness of the sheet. The length and breadth of the particles ranges from 1.5 microns down to a few tenths of a micron. However, the thickness is astoundingly small, measuring only about a nanometer (a billionth of a meter). These dimensions result in extremely high average aspect ratios (200 - 300). Moreover, the nanoscale size and thickness mean that a single gram contains over a million individual particles.

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How Nanoclays Work:

Composite producers are well aware of the benefits of high aspect ratio fillers. But only recently have science and industry discovered the magnifying effect of combining aspect ratio and nanoscale size. Because nanometer-sized particles approach the scale of resin molecules, a very close encounter can be made between the two materials when the mineral is properly surface modified. The particle-molecule interaction creates a constrained region at the particle surface, which immobilizes a portion of the resin matrix. With so many particles available for interactive association, the cumulative percent of constrained polymer can become large. In nylon resin systems, for example, the constrained region exceeds 50% of the total matrix.

Nanomer Nanoclays in Reinforcement:

The ratio of mechanical properties versus filler loading is high for nanocomposites. 3% mineral loading can double flexural modulus and heat distortion with minimal loss in toughness. In some systems the glass transition temperature can be increased 10-20C. Nanocomposites are amenable to combination reinforcement with other common fillers such as glass fiber. The composite designer has greater flexibility in making resins strong but lighter since the density of the composite is reduced by such an effective reinforcer.

Nanomer Nanoclays in Barrier Enhancement:

Gas barrier can increase dramatically, depending on the resin. Exfoliated Nanomer particles are not only extremely small but also flexible. They will orient in the direction of extrusion. Films remain transparent because the wavelength of visible light exceeds the thickness of Nanomer particles. Gas permeabilities can be reduced by 30%-300% using as little as 3% mineral. Although Nanomer nanoclay's ability to elongate mimics elongation loss, it will vary with loading level, degree of exfoliation and host resin.

For more information on how Nanomer® nanoclays can work for you, contact Nanocor's Technical Service Group.

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